EUV lithography into production at chipmakers ~update on ASML's NXE platform~

June 2011

Content

- ASML EUVL product roadmap
- Status NXE:3100
- Status NXE:3300B
- Summary

2 Alpha-demo tools used by multiple customers since 2006

imec

College of Nanoscale Science & Engineering
University at Albany State University of New York

λ	13.5 nm
NA	0.25
Field size	26 x 33 mm²
Magnification	4x reduction
Sigma	0.5

- 300mm Single stage
- linked to track
- Single reticle load
- Uses TWINSCAN technology
- Sn discharge source

SONY intel Micron
hynix GLOBALFOUNDRIES
Panasonic SAMSUNG
SEMATECH ELPIDA
TOSHIBA
tsmc PSC
IBM Infineon ASML

ASML EUV Product Roadmap and Technology Status

NXE:3300 numerical aperture increased to 0.33

	2006 Proto System	2011 NXE:3100	2012 NXE:3300B	2013 NXE:3300C
Resolution	32 nm	27 nm	22 nm	18/16* nm
NA / σ	0.25 / 0.5	0.25 / 0.8	0.33 / 0.2-0.9	0.33 / OAI
Overlay (DCO/MMO)	< 7 nm	< 4/7 nm	< 3/5 nm	< 2.5/4.5 nm
Throughput W/hr	4 W/hr	60 W/hr	125 W/hr	150 W/hr
Dose, Source	5 mJ/cm^2, ~8 W	10 mJ/cm^2, >100 W	15 mJ/cm^2, >250 W	15 mJ/cm^2, >350 W

Main improvements

1) New EUV platform: N

2) Improved low flare op

3) New high sigma illum

4) New high power sour

5) Dual stages

- ***Imaging 22nm demonstrated***
- ***Overlay <4/7nm shown***
- ***Productivity improvement plan in place to achieve spec Q3 2011***
- ***Ultimate source performance to be achieved***

- ***Building of frames and optics has started***

optional

se

enhancements

illumination

power increase

* Requires <7 nm resist diffusion length

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New EUV facilities planned to be available end 2011

NXE production capacity increases ~3x

Existing EUV offices & manufacturing, 8 cabins.

New EUV offices & manufacturing,15 cabins.

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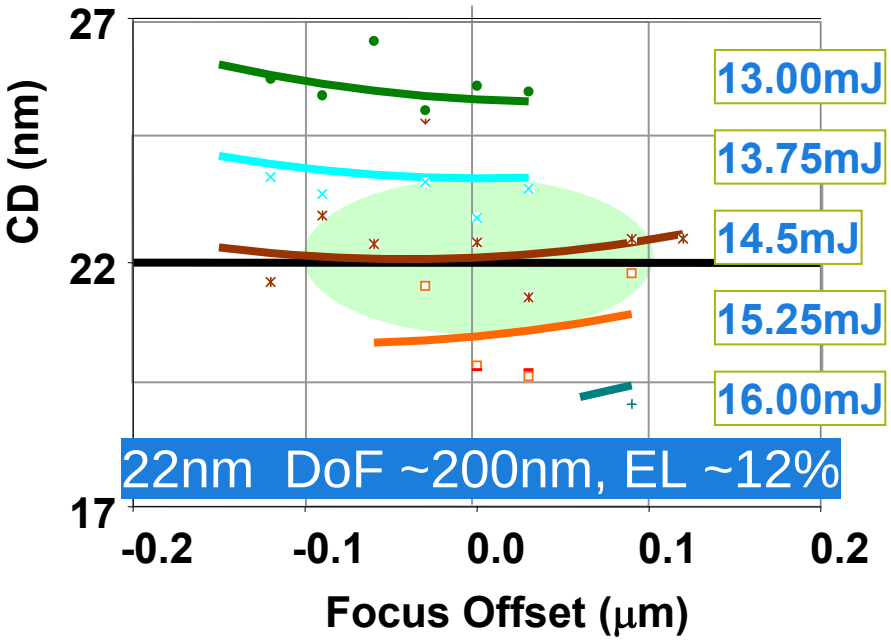
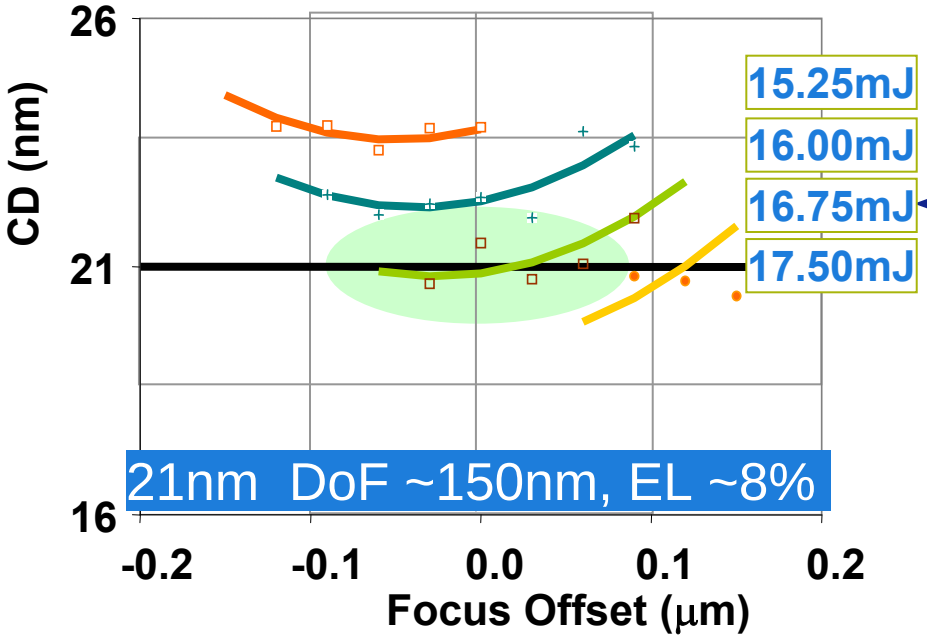
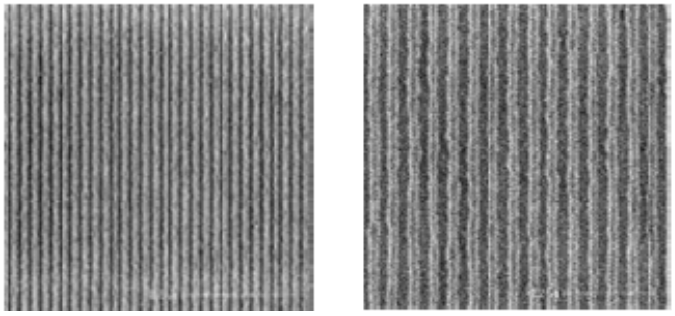
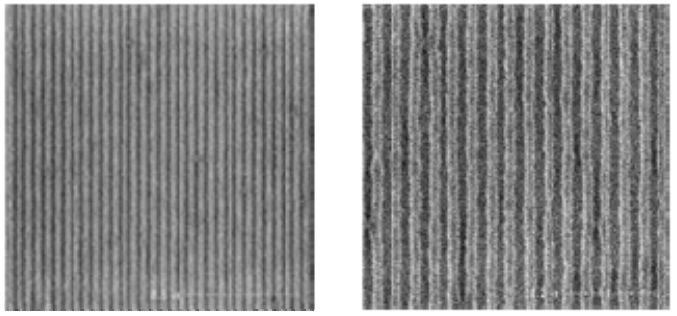
NXE:3100 Large Process windows

NA=0.25, 75deg dipole, resist dose ~15mJ/cm2



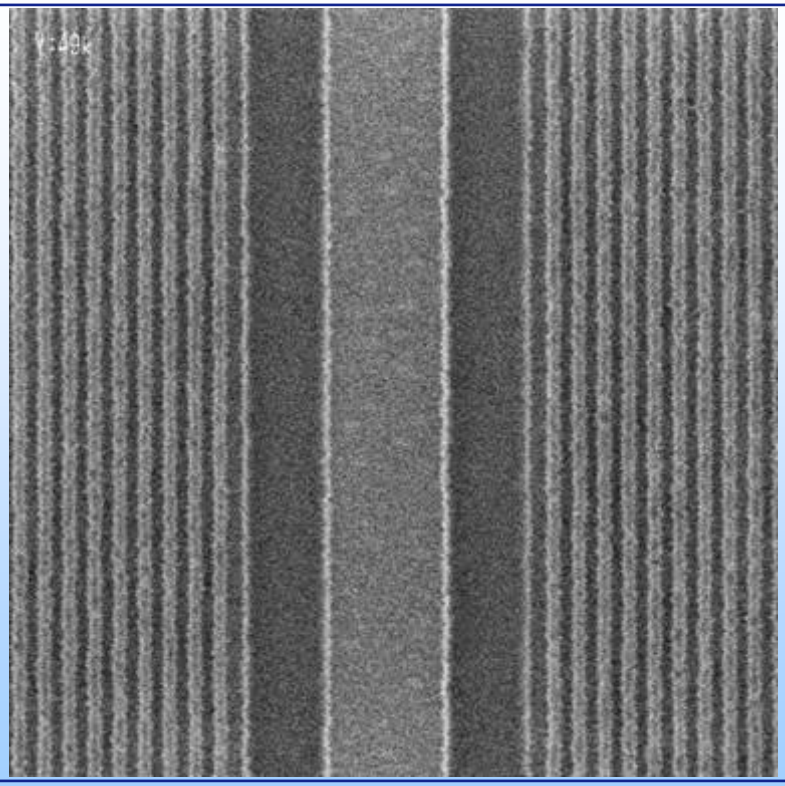
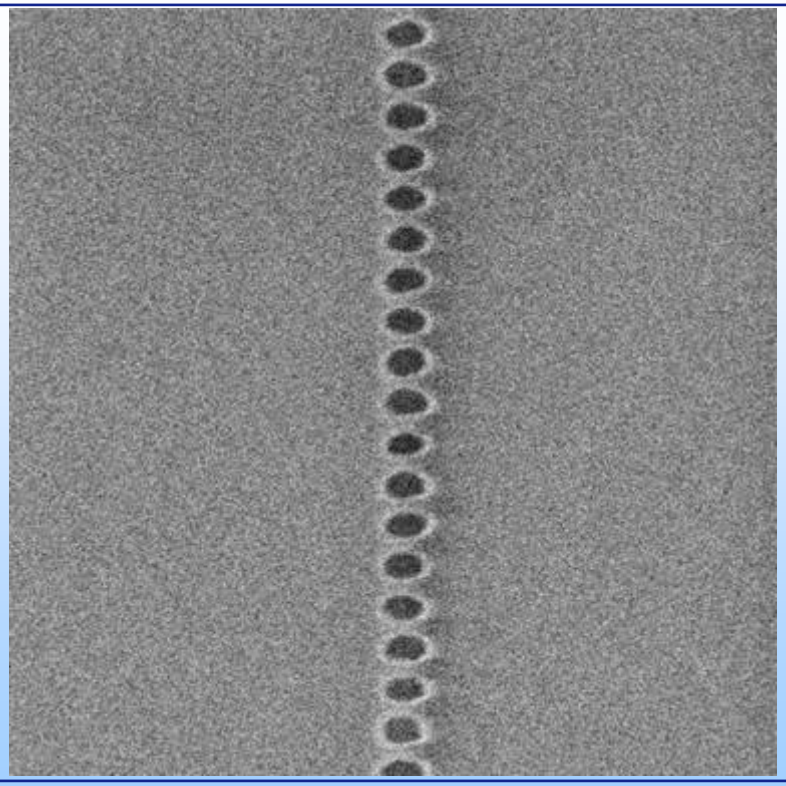






SEVR140 SB/PEB : 105°C/95°C

22nm node Flash gate and contact layer well resolved using Dipole-75-X

22nm node Flash wordline	22nm node Flash CHs – 1.5x3f
	
Wordline pitch = 44nm	CH pitch = 48nm Bitline pitch = 48nm

50nm SPUR-V002 on 20nm UL, TBAH develop + DIW rinse
Dose L/S = 9.5mJ/cm² / Dose CHs = 13.0mJ/cm2

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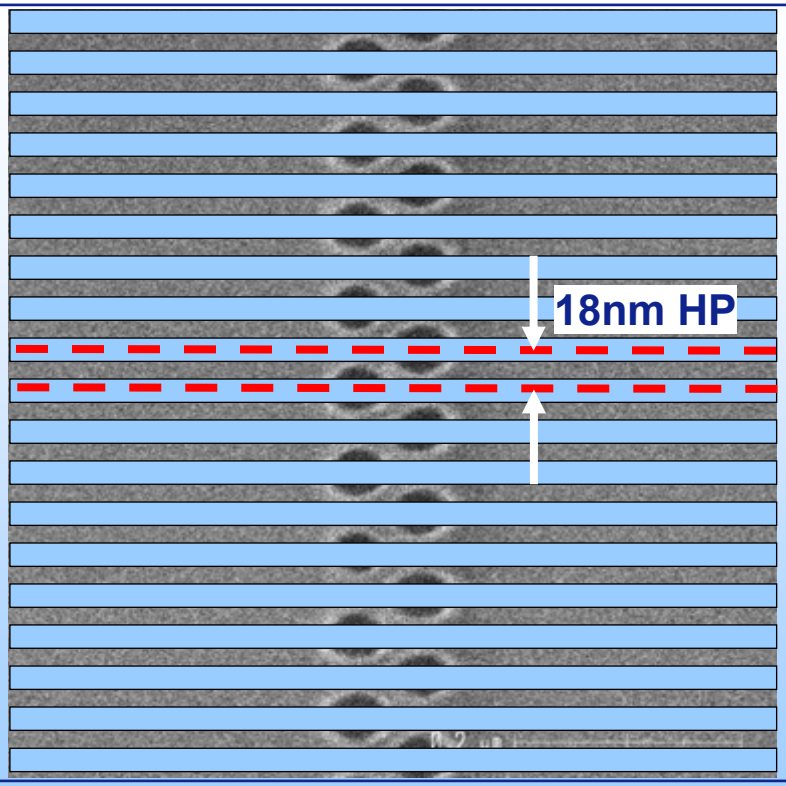
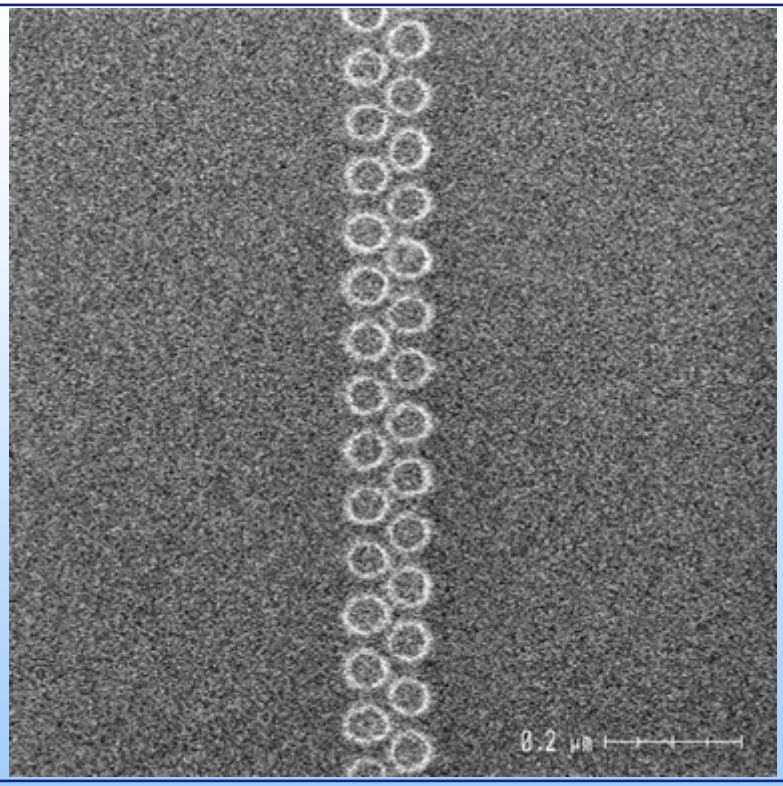
18nm node Flash staggered contact layer well resolved

18nm node Flash CHs – 1.5x3f	20nm node Flash CHs – 1.5x2f
	
Bitline pitch = 36nm CH pitch = 65nm	Bitline pitch = 40nm CH pitch = 72nm

50nm SPUR-V002 on 20nm UL, TBAH develop + FIRM Extreme rinse
Dose = 20.0 mJ/cm²

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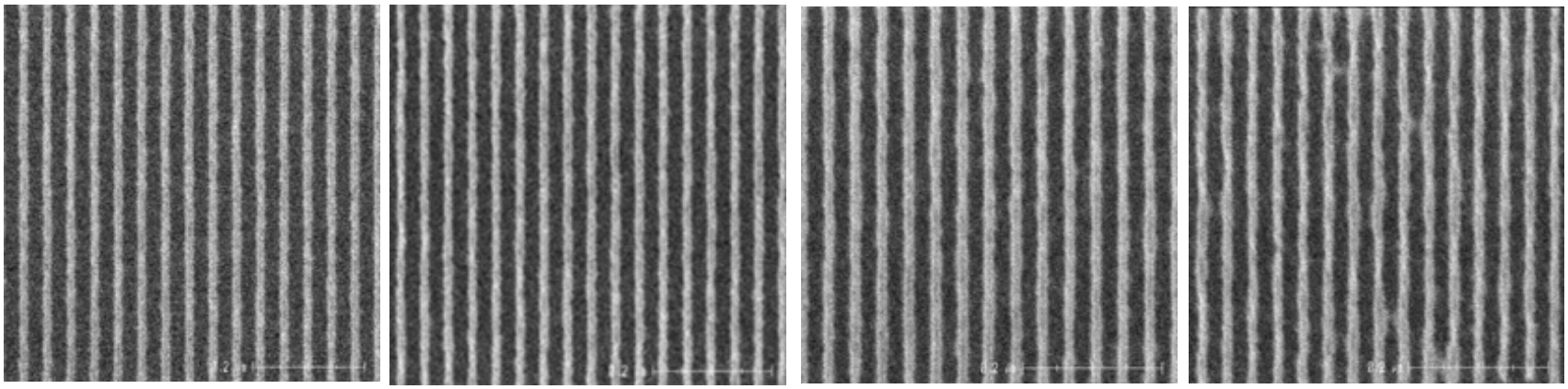
Further Resolution extension with 0.25NA

Supports resist and process development for NXE:3300

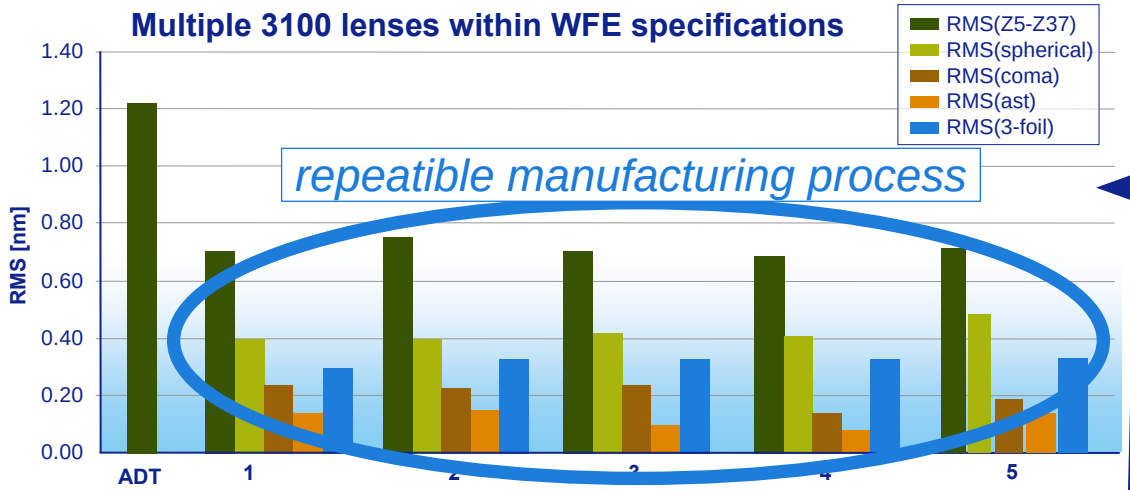


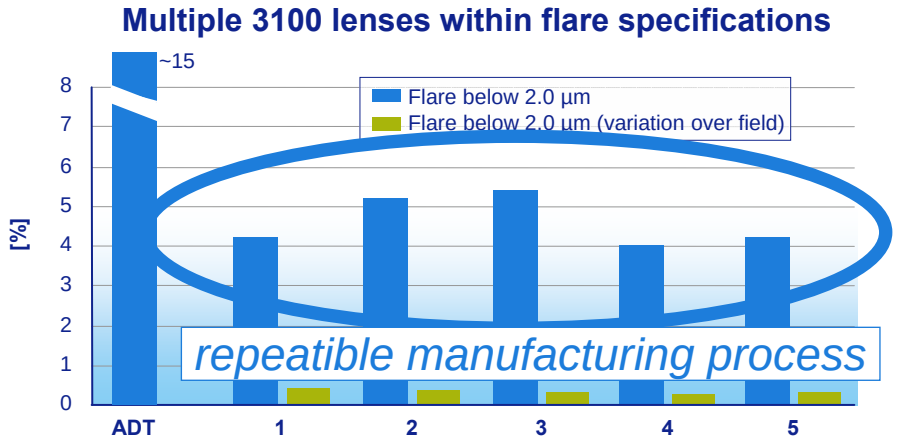
21 nm 20 nm 19 nm 18 nm

Source: in collaboration with IMEC, resist Inpria

Multiple 3100 lenses manufactured and qualified

Wavefront qualified by EUVL interferometer





- NA: 0.25
- Field size: 26mm
- Chief ray at mask: 6°
- 4x reduction ring field design
- Design is extendable to higher NA

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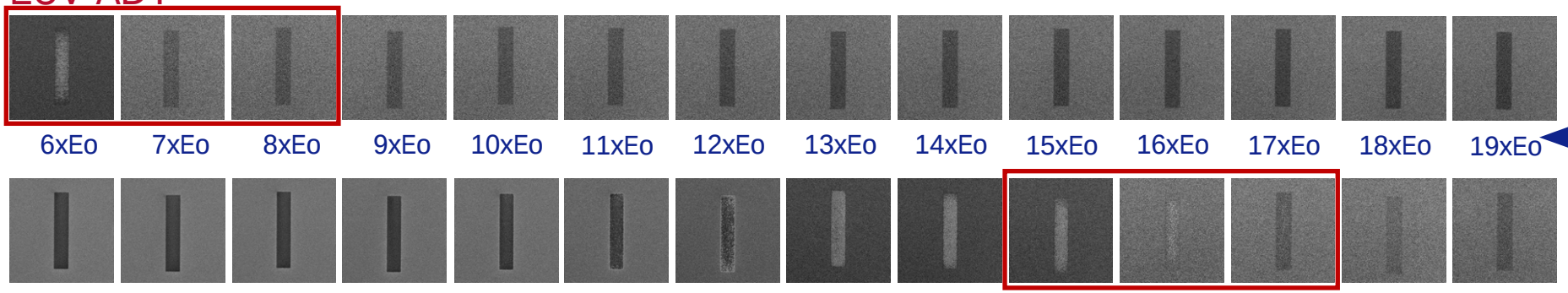
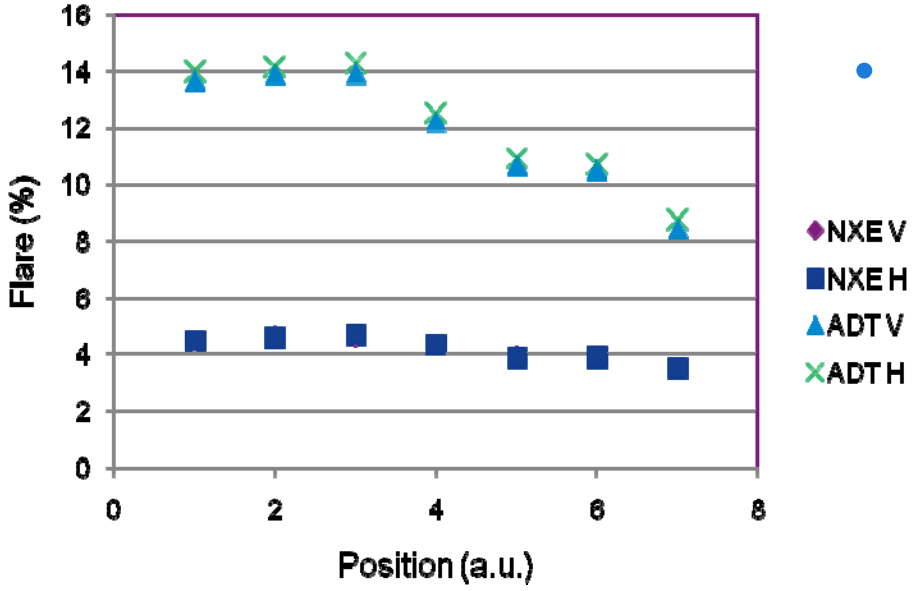
NXE:3100 flare measurement in resist confirms optical measurements of <5%

EUV ADT



NXE 3100

Edtd

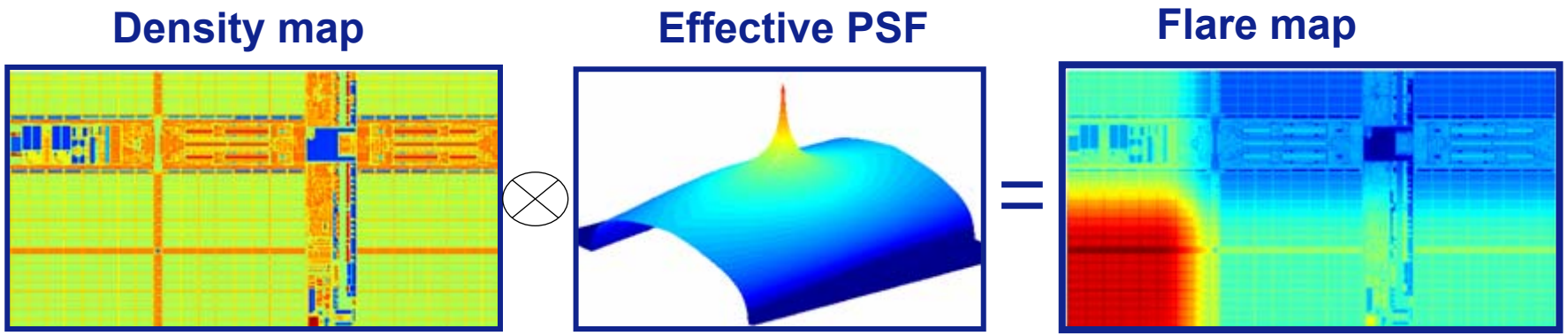


- **Methodology:**
  - **Dose to clear resist in open frame: Eo**
  - **Dose to disappear the pattern Edtd**
  - **Flare = Eo/Edtd- mask flare**

NXE:3100 imaging optimized with specific OPC
taking care of shadowing and flare

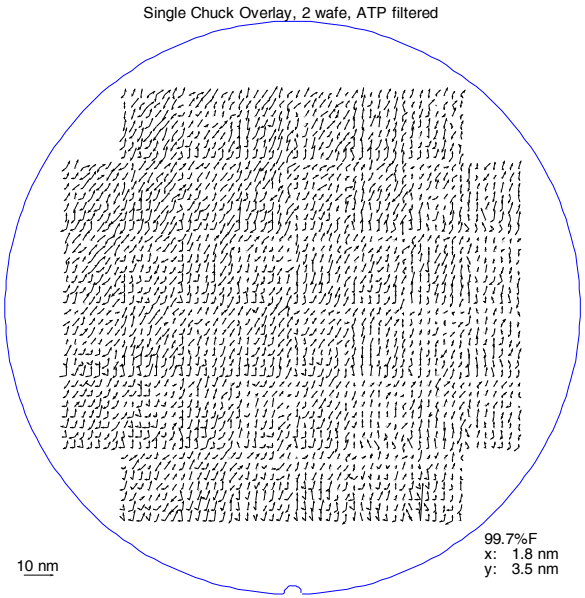
- Mask shadowing and aberrations are local effect, affecting all features in a systematic (model based) way -> adapt today's OPC models

- Flare is mask dependent long range and in/out-of field effect -> new OPC models



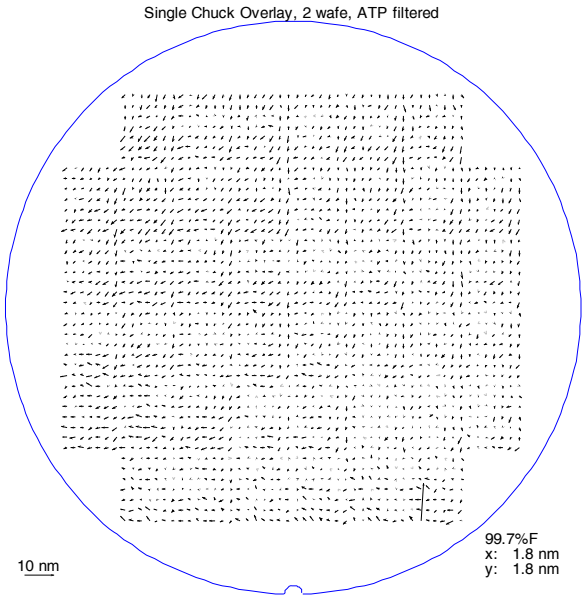
Pilot 2: Single Chuck Overlay < 4nm !
Champion wafer: <2nm!

Wafer 1&2, "ATP"



(x:1.8,y:3.5)

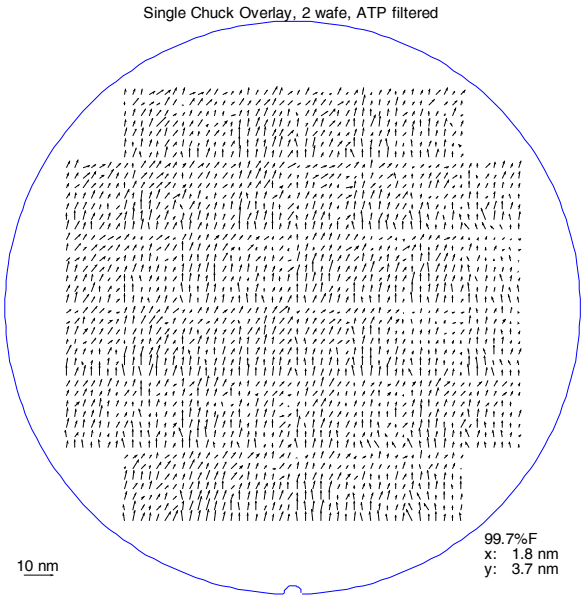
Wafer 1



(x:1.8,y:1.8)

Layer 1: 1st from lot
Layer 2: 1st from lot

Wafer 2



(x:1.8,y:3.7)

Layer 1: 2nd from lot
Layer 2: 1st from lot

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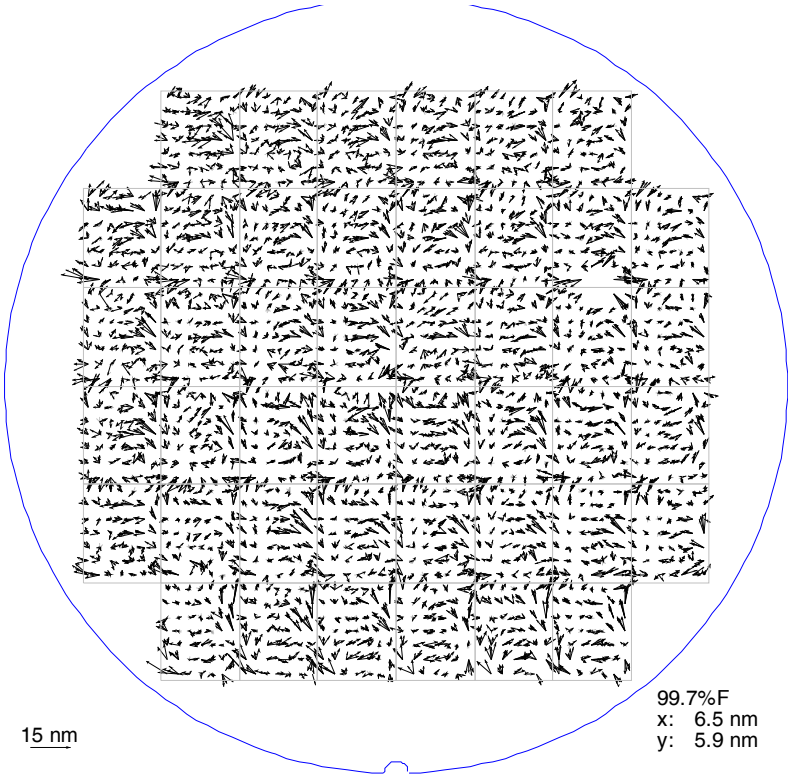
EUV-to-dry-193 Overlay measured at 6.5 nm

NXE:3100 to XT:1450



4 wafers: (x:6.5,y:5.9)

Standard system calibration, 44 fields, 99.7%

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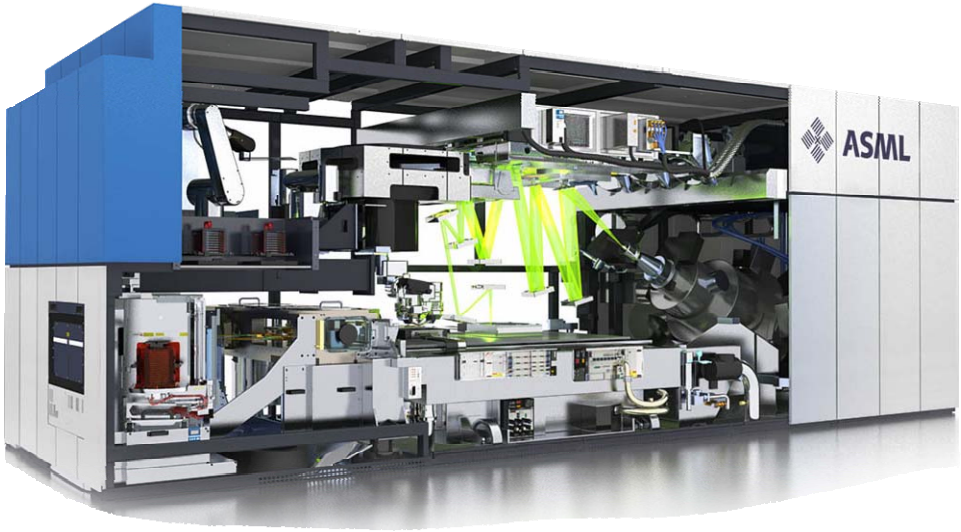
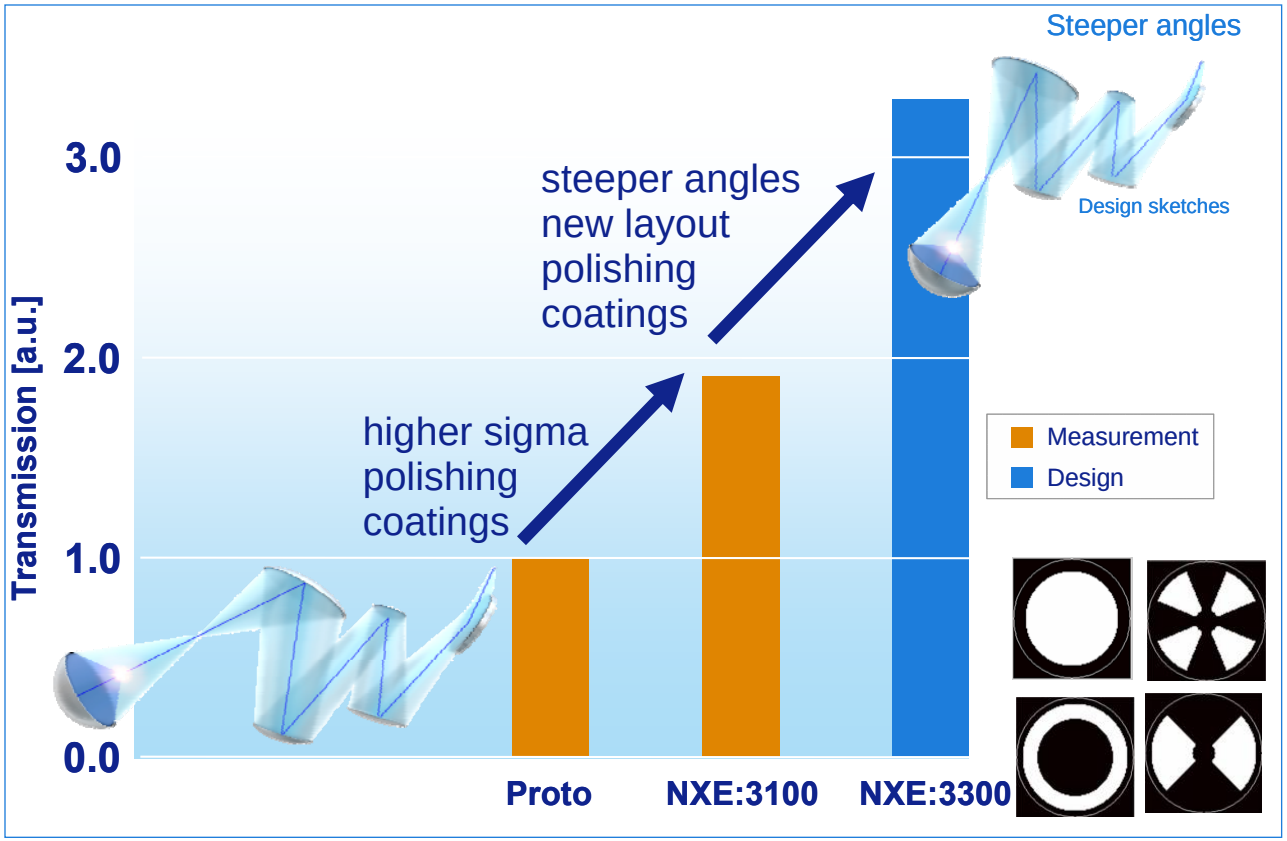
NXE:3300B baseline development approach builds on the 3100

- The NXE:3300B is a continuation of the 3100 platform, with a changed optical column and reduced footprint to enable
  - Improved resolution (0.33NA), capability for off-axis illumination without energy loss, higher productivity at higher dose.
- Consequence: stages, handlers, SW, EL, sensors, etc. all are re-used from 3100 for 3300B.



System performance	NXE:3300B
NA	0.33
Resolution (half-pitch)	22 nm (18 nm with OAI)
Overlay (DCO / MMO)	3.0 / 5.0 nm
Throughput	125 wph @ 15 mJ/cm^2

NXE:3300 - System Transmission significantly improved
- Flexible Off-Axis illumination
- Six mirror lens extension from NXE:3100



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Steps to reduce risk of productivity roadmap

- Source Power and Availability:
  - Risk reduction for NXE3300: additional source supplier.
  - Source power roadmap is aligned with all three source suppliers.
  - Scanner interface is generic by design for all three source suppliers.
  - Source technology from 3100 will be transferred to 3300B layout → learning from 3100 is directly applicable to first 3300B source.

- Scanner Availability:
  - Proven way-of-working within ASML: ensure *platform* development, maximizing commonality.
    - 3100 WS, WH, RS, RH, etc. modules will be transferred to 3300B
  - Additional Wafer Stage test setup to qualify WS at 0.3 m/s scan speed (i.s.o. 0.1 m/s for 60wph NXE:3100) and test its reliability.
  - Rigorous testing on a daily basis on multiple systems results in evolutionary improvements in reliability. Way-of-working in place since TWINSCAN introduction.

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Summary and key messages

- NXE:3100 is operational on-site customer
  - 4 systems accepted by customers
  - Imaging and overlay meet expectations.
  - Productivity does not meet expectations, due to reduced source power and -availability.
- NXE:3300B integration path is made independent of 3300B source progress
  - throughput in first phase therefore lower.
- Main Body Frame manufacturing is in final phase.
- Optics manufacturing at Zeiss in progress
- ASML NXE manufacturing infrastructure under construction, to be available end 2011.